TMDL FOR DISSOLVED OXYGEN AND NUTRIENTS FOR FLAT RIVER SUBSEGMENT 100406

MARCH 24, 2008

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FOR FLAT RIVER
SUBSEGMENT 100406

Prepared for

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Contract No. 68-C-02-108
Task Order 95

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March 24, 2008

EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires states to identify waterbodies that are not meeting water quality standards and to develop total maximum daily pollutant loads (TMDL) for those waterbodies. A TMDL is the amount of pollutant that a waterbody can assimilate without exceeding the established water quality standard for that pollutant. Through a TMDL, pollutant loads can be distributed or allocated to point sources and nonpoint sources (NPS) discharging to the waterbody. This report presents TMDLs that have been developed for dissolved oxygen (DO) and nutrients for Flat River (Subsegment 100406), in the Red River basin in northern Louisiana.

Flat River Subsegment 100406 extends approximately 87 km (54 mi) from its upstream end north of Shreveport, Louisiana, near Black Lake, in a southeasterly direction, roughly parallel to the Red River channel, to Loggy Bayou. Subsegment 100406 covers approximately 117 mi^2 and is about 60% agricultural.

Subsegment 100406 was listed as impaired on the final 2004 303(d) List for Louisiana dated August 17, 2005 (Louisiana Department of Environmental Quality (LDEQ) 2005) as not fully supporting the designated uses of primary contact recreation and propagation of fish and wildlife and was ranked as priority No. 2 for TMDL development. The causes for impairment cited in the 303(d) List included nutrients and low DO. The water quality criterion for DO in this subsegment is 5 mg/L year round. Louisiana has not currently specified nutrient criteria for this subsegment.

A water quality model (LA-QUAL) was set up to simulate DO, carbonaceous biochemical oxygen demand (CBOD), ammonia nitrogen, and organic nitrogen in the subsegment. The model was set up and calibrated using observations from a synoptic survey conducted by FTN Associates, Ltd. (FTN) during August through September 2005, and other information obtained from LDEQ and United States Geological Survey (USGS). Projection simulations for summer and winter were run at critical flows and temperatures to address seasonality as required by the Clean Water Act. Reductions of existing NPS loads were required for the projection simulations to show the DO criterion of 5 mg/L being maintained. In general, the modeling in this study was consistent with guidance in the Louisiana TMDL Technical Procedures Manual.

TMDLs were calculated for dissolved oxygen, total phosphorus, and total nitrogen. TMDLs for oxygen-demanding substances (CBOD, ammonia nitrogen, organic nitrogen, and sediment oxygen demand) were calculated using the results of the projection simulations (Table ES.1). Both implicit and explicit margins of safety were included in the TMDL calculations, along with a 10% future growth component. The nutrient TMDL was calculated using the allowable nitrogen loadings from the DO modeling and the naturally occurring ratio of total nitrogen to total phosphorus from reference streams in the South Central Plain Ecoregion. The nutrient TMDL also included a 10% explicit margin of safety and a 10% future growth allowance (Table ES.1). Thirty-five point sources were identified in Subsegment 100406, but only 12 of them were included in the DO TMDL and 10 were included in the nutrient TMDL; the other point sources were considered to have negligible contributions of oxygen demand or nutrients. The allowable loads and concentrations for point sources in these TMDLs are shown in Tables ES.2 and ES.3.

In order to maintain the DO standard of 5.0 mg/L throughout the subsegment, summer nonpoint source oxygen demand loads will need to be reduced 75% to 92% and winter loads will need to be reduced 3% and 49%. Because the Flat River average total phosphorus and total nitrogen concentrations were higher than the average concentration in the reference streams, nutrient loads also need to be reduced.

It is recommended that as a first step to implement this nutrient TMDL, the point sources should be given nutrient monitoring requirements in their permits to determine if the point sources are causing or contributing nutrients. However, final decisions for point source nutrient limitations will be made by LDEQ on a case-by-case basis during the re-issuance of each permit. Because point source discharges represent a very small portion of the total nutrient loading, it is possible that no reductions of point source discharges may be needed as a result of this TMDL.

Table ES1. Summer and Winter DO and Nutrient TMDLs for Subsegment 100406.

Parameter	Loads, lbs/day				
	WLA	LA	MOS	FG	TMDL
Oxygen Demand (summer)	433.91	4351.53	598.18	598.18	5981.84
Oxygen Demand (winter)	376.84	9087.82	1179.33	1179.33	11793.32
Total Phosphorus (summer)	10.722	4.235	1.870	1.870	18.697
Total Phosphorus (winter)	10.722	43.334	6.757	6.757	67.570
Total Nitrogen (summer)	107.22	42.35	18.7	18.7	186.97
Total Nitrogen (winter)	107.22	433.34	67.57	67.57	675.70

Table ES.2. Flows, concentrations, and loads for point sources included in DO TMDL.

NPDES Number	Name of discharger	Flow rate (gallons per day)	Concentrations			Loads*		
			BOD_5 or COD (mg/L)	Ammonia nitrogen (mg/L)	Organic nitrogen (mg/L)	BOD_5 or COD (lbs/day)	Ammonia nitrogen (lbs/day)	Organic nitrogen (lbs/day)
LAG560083	River Ridge Subdivision	50000	20	7	3	8.23	2.89	1.23
LA0102890	Palmetto Park	400000	10	3	7	33.37	10.02	23.37
LAG540188	Elm Grove Jr. High	25000	30	10	5	6.40	2.13	1.06
LAG480035	La Military Dept	46000	200	0	0	33.09	0	0
LAG480223	La Machinery Co. Inc.	1000	200	0	0	0.58	0	0
LAG540038	Jeff Hall Ministries	10000	30	0	0	2.43	0	0
LAG540494	Maplewood Park	25000	30	0	0	6.26	0	0
LAG541141	Magnolia Chase Subdivision	21000	30	0	0	5.21	0	0
LAG541272	Haymeadow Subdivision	9000	30	0	0	2.20	0	0
LAG541293	St Charles Court	23000	30	0	0	5.80	0	0
LAG560063	Oak Creek Devel	50000	20	0	0	8.34	0	0
LAG470050	Red River Motor Co	2000	45	0	0	0.63	0	0
Total Loads:						112.54	15.02	25.66

*Loads of organic nitrogen and ammonia nitrogen in this table represent loads of nitrogen, not oxygen demand.

Table ES.3. Nutrient Point Source Loads.

			Concentrations		Loads	
NPDES Number	**Name of Discharger**	**Flow Rate (gpd)**	**Total Nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**Total Nitrogen (lbs/day)**	**Total Phosphorus (lbs/day)**
LA0102980	River Ridge Subdivision	50000	20.00	2.00	83.44	8.344
LAG560083	Palmetto Park	400000	19.98	2.00	10.27	1.027
LAG540188	Elm Grove Jr. High	25000	24.97	2.50	6.66	0.666
LAG540038	Jeff Hall Ministries	10000	25.10	2.51	2.51	0.251
LAG540494	Maplewood Park	25000	24.98	2.50	6.46	0.646
LAG541141	Magnolia Chase Subdivision	21000	25.00	2.50	5.42	0.542
LAG541272	Haymeadow Subdivision	9000	24.98	2.50	2.29	0.229
LAG541293	St Charles Court	23000	24.97	2.50	6.04	0.604
LAG560063	Oak Creek Devel	50000	20.01	2.00	10.52	1.052
LAG470050	Red River Motor Co	2000	25.10	2.51	0.42	0.042
Subsegment 100406 TOTAL LOADS:					107.22	10.722

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1.0 INTRODUCTION

This report presents total maximum daily loads (TMDL) for dissolved oxygen (DO) and nutrients for Subsegment 100406 (Flat River from the headwaters to Loggy Bayou). This subsegment was listed as impaired on the final 2004 303(d) List for Louisiana dated August 17, 2005 (Louisiana Department of Environmental Quality (LDEQ) 2005). Table 1.1 shows the suspected sources and suspected causes for impairment in the 303(d) List, as well as the priority ranking. The TMDLs in this report were developed in accordance with Section 303(d) of the Federal Clean Water Act and the United States Environmental Protection Agency's (US EPA) regulations at 40 CFR 130.7. The 303(d) listings for other pollutants in this subsegment are being addressed by US EPA and LDEQ in other documents.

The purpose of a TMDL is to determine the pollutant loading that a waterbody can assimilate without exceeding the water quality standard for that pollutant and to establish the load reduction that is necessary to meet the standard in a waterbody. The TMDL is the sum of the wasteload allocation (WLA), the load allocation (LA), and a margin of safety (MOS). The WLA is the load allocated to point sources of the pollutant of concern, and the LA is the load allocated to nonpoint sources (NPS), including natural background. The MOS is a percentage of the TMDL that accounts for the uncertainty associated with the model assumptions, data inadequacies, and future growth (FG).

Table 1.1. Summary of 303(d) listing for Subsegment 100406 (LDEQ 2005, US EPA 2005).

Subsegment Number	Waterbody Description	Suspected Sources	Suspected Causes	Priority Ranking (1 = highest)
100406	Flat River	Unknown source	Organic enrichment/low DO	2
		Unknown source	Nutrients	2

2.0 STUDY AREA DESCRIPTION

2.1 General Information

Flat River (Subsegment 100406) is located in northwestern Louisiana in the Red River Basin (see Figure A.1 in Appendix A). Within this subsegment, Flat River extends approximately 54 km (34 mi) from its headwaters north of Shreveport, Louisiana, near Black Lake, in a southeasterly direction, roughly parallel to the Red River channel, to Loggy Bayou. One of the significant tributaries to Flat River within Subsegment 100406 is Red Chute Bayou. Subsegment 100406 covers 117 mi^2.

2.2 Land Use

Land use characteristics for the study area were compiled from the United States Geological Survey (USGS) National Land Cover Dataset (USGS 2000). Although these data were based on satellite imagery from the early 1990's, there are no land use data for this area that are more recent. The spatial distribution of these land uses is shown on Figure A.2 (located in Appendix A) and land use percentages are shown in Table 2.1. These data indicate that most of Subsegment 100406 is agricultural.

Table 2.1. Land use percentages for Subsegment 100406.

Land Use Type	% of Total Area
Water	0.8%
Urban/Transportation	12.3%
Barren	0.14%
Forest	11.8%
Shrubland/grassland	3.1%
Pasture/hay	17.1%
Row crops	43.8%
Small grains	0%
Wetlands	10.9%
TOTAL	**100.0%**

2.3 Water Quality Standards

Water quality standards for Louisiana are listed in the Title 33 Environmental Regulatory Code (LDEQ 2007). The designated uses for Subsegment 100406 are primary contact recreation, secondary contact recreation, and propagation of fish and wildlife. The primary numeric criteria for the DO TMDL presented in this report are the DO criterion of 5 mg/L (year round) and the temperature criterion of 32°C.

The Title 33 Environmental Regulatory Code does not include numeric criteria for nutrients, but it does include the following narrative criteria for nutrients (LAC 33: IX.1113.B.8):

> "The naturally occurring range of nitrogen-phosphorous ratios shall be maintained. This range shall not apply to designated intermittent streams. To establish the appropriate range of ratios and compensate for natural seasonal fluctuations, the administrative authority will use site-specific studies to establish limits for nutrients. Nutrient concentrations that produce aquatic growth to the extent that it creates a public nuisance or interferes with designated water uses shall not be added to any surface waters."

The Louisiana water quality standards also include an antidegradation policy (LAC 33: IX.1109.A). This policy states that waters exhibiting high water quality should be maintained at that high level of water quality. If this is not possible, water quality of a level that supports designated uses of the waterbody should be maintained. Changing the designated uses of a waterbody to allow a lower level of water quality can only be achieved through a use attainability study.

2.4 Point Sources

A list of point sources in selected portions of the Red River basin was developed using data from LDEQ's internal point source databases with additional information obtained from LDEQ's Electronic Document Management System (EDMS). Using this information, 35 point sources were identified within Subsegment 100406 (Appendix B). Those point sources that have permit limits for oxygen demand (BOD_5) and discharge directly to Flat River were included in the model. Approximate locations of the point sources are shown on Figure A.3 (in Appendix A).

Stormwater runoff from areas within the Shreveport city limits is classified as a point source for this TMDL because the City Shreveport has a Municipal Separate Storm Sewer System (MS4) permit (permit number LAS000401). The Urbanized Area for Shreveport (EPA 2002) extends into Subsegment 100406 and covers approximately 28 square miles of the upper part of the subsegment. This MS4 permit does not set numeric limits for the quality of stormwater runoff from urban areas, but it does require the City of Shreveport to identify and implement best management practices (BMPs) to minimize pollutants in stormwater runoff.

2.5 Nonpoint Sources

In the final 2004 303(d) List, no specific NPS were cited as suspected sources for the nutrients and organic enrichment/low DO impairment (Table 1.1). Urban runoff and agricultural activities may contribute some NPS pollution to Flat River.

2.6 Historical Water Quality Data Summary

There are four LDEQ routine water quality monitoring stations in this subsegment; Station 272 (Flat River east of Taylortown, Louisiana), Station 363 (Flat River Drainage Canal north of Bossier City, Louisiana), Station 389 (Flat River Drainage Canal northeast of Bossier City, Louisiana), and Station 390 (Flat River Drainage Canal northeast of Shreveport, Louisiana). The DO and nutrient data from these monitoring stations are summarized in Table 2.2 below and the individual data are listed in Appendix C. Eighteen DO measurements at Station 272 from the 1990s and 2002 were below the water quality standard of 5.0 mg/L (30%). The water quality monitoring station locations are shown on Figure A.1 in Appendix A.

2.7 Previous Studies

No previous studies were identified for Flat River Subsegment 100406.

Table 2.2. Summary of LDEQ routine water quality monitoring data.

LDEQ Station No.	Station Description	Period of Record	Parameter	Number of values	Min.	Avg.	Median	Max.
272	Flat River east of Taylortown, LA	Feb. 1990-Jan 2007	DO	61	2.59	6.17	6.30	9.90
			NO2-NO3	60	<0.02	0.17	0.11	1.09
			Total Phos.	59	<	0.40	0.21	7.91
			TKN	59	<0.02	0.88	0.75	6.92
389	Flat River Drainage Canal northeast of Bossier City, LA	Nov. 1990-Dec. 1994	NO2-NO3	49	<0.02	0.11	0.04	0.62
			Total Phos.	49	0	0.48	0.46	1.28
			TKN	49	0	1.13	1.07	3.67
390	Flat River Drainage Canal northeast of Shreveport, LA	Nov. 1990-Dec. 1994	NO2-NO3	48	<0.02	0.17	0.08	1.08
			Total Phos.	48	0	0.51	0.46	1.26
			TKN	48	0	1.21	1.17	2.65
363	Flat River Drainage Canal north of Bossier City, LA	Nov. 1990-Dec. 1994	NO2-NO3	50	<0.02	0.14	0.08	1.15
			Total Phos.	50	0	0.35	0.28	1.37
			TKN	49	0	0.91	0.88	1.92

3.0 FTN FIELD DATA

FTN conducted a field survey for 14 subsegments in the Red River and Sabine River basins during August 31 through September 9, 2005. Low flow conditions existed throughout the survey area during this time. The survey was conducted after Hurricane Katrina and before Hurricane Rita. Hurricane Katrina did not cause any noticeable impacts on water quality in the survey area. Field data were collected in the Flat River subsegment on August 31 through September 2, 2005.

The field survey included water quality sampling and corresponding in situ measurements at various locations; measurements of flow, depth, and width at several locations; and continuous in situ monitoring at several locations. The water quality samples were analyzed for 20-day time series for carbonaceous biochemical oxygen demand (CBOD), total Kjeldahl nitrogen (TKN), ammonia nitrogen (NH3-N), nitrate+nitrite nitrogen, total phosphorus, chlorophyll *a*, total organic carbon (TOC), and total suspended solids (TSS). A list of the survey sites and the type of data collected at each site is presented in Table C.1 (in Appendix C). The in situ measurements and water quality sampling results are summarized in Tables C.2 and C.3, respectively. The calculations of CBOD decay rates and ultimate CBOD (CBODu) concentrations from the time series data are shown in Table C.4.

For the Flat River subsegment, field data were collected at LDEQ Stations 363, 389, 390, and 272 and at Station 100406-A (locations shown on Figure A.1 in Appendix A). The field data collected at these two sites are listed in Table 3.1. The DO concentrations measured in Flat River ranged from 0.37 mg/L to 5.26 mg/L. Measurable flows occurred only during the period when releases from Black Bayou Reservoir were being discharged to Flat River. Locals reported that this was a very rare occurrence.

Table 3.1. FTN field data collected for Subsegment 100406.

	Station 363	**Station 363**	**Station 389**	**Station 390**	**Station 272**	**Station 100406-A**
Date and time of sample / measurements	9/1/05 9:30 am	-	9/1/05 7:54 am	9/1/05 8:40 am	9/2/05 8:15 am	8/31/05 7:00 pm
Depth (m) of sample / measurements	mid-depth (0.2 m)	-	0.1 m	0.3 m	mid-depth (0.3 m)	mid-depth (0.1 m)
Width of stream (ft)	43	-	23	30	43.5	39.4
Mean depth of stream (ft)	1.80	-	1.07	1.48	1.32	0.56
Stream flow rate (cfs)	41.9*	-	Too low to measure	Too low to measure	7.43*	Too low to measure
Water temperature (°C)	29.28	-	26.9	27.11	25.5	30.57
DO (mg/L)	5.16	-	1.44	0.37	2.87	5.26
Conductivity (µmhos/cm)	90.0	-	335.7	178.9	810.9	887.6
pH (su)	7.10	-	7.62	7.17	7.14	7.25
TSS (mg/L)	26	26	-	-	-	-
TKN (mg/L)	2.5	2.2	-	-	-	-
Total phosphorus (mg/L)	0.093	0.074	-	-	-	-
TOC (mg/L)	10	11	-	-	-	-
Chlorophyll *a* (mg/L)	0.027	0.03	-	-	-	-
NH3-N (mg/L)	0.39	0.36	-	-	-	-
Nitrate+nitrite nitrogen (mg/L)	<0.05	<0.05	-	-	-	-
CBOD on day 3 of analysis (mg/L)	<2	<2	-	-	-	-
CBOD on day 5 of analysis (mg/L)	<2	<2	-	-	-	-
CBOD on day 9 of analysis (mg/L)	4.3	4.2	-	-	-	-
CBOD on day 14 of analysis (mg/L)	5.7	5.8	-	-	-	-
CBOD on day 20 of analysis (mg/L)	6.6	6.8	-	-	-	-
Ultimate CBOD (mg/L; calculated)	7.50	7.69	-	-	-	-
CBOD decay rate (1/day; calculated)	0.12	0.12	-	-	-	-

Note: *Releases from Black Bayou Reservoir.

4.0 CALIBRATION OF WATER QUALITY MODEL

4.1 Model Setup

In order to evaluate the linkage between pollutant sources and water quality, a computer simulation model was used. The model used for these TMDLs was LA-QUAL (Version 6.1), which was selected because it includes the relevant physical, chemical, and biological processes and it has been used successfully in the past for other TMDLs in Louisiana. The LA-QUAL model was set up to simulate organic nitrogen, ammonia nitrogen, ultimate carbonaceous biochemical oxygen demand (CBODu), and DO.

Figure D.1 in Appendix D shows the model reach/element design and the location of the modeled inflows. Flat River was divided into five reaches to represent varying depths and widths along the stream.

4.2 Calibration Period and Calibration Targets

Routine water quality monitoring has been conducted at four LDEQ sampling stations in Subsegment 100406: Station 363 (Flat River Drainage Canal north of Bossier City), Station 390 (Flat River Drainage Canal northeast of Shreveport), Station 389 (Flat River Drainage Canal northeast of Bossier City) and Station 272 (Flat River east of Taylortown). An intensive survey of this subsegment was performed by FTN August 31 through September 2 of 2005. The water quality data collected by LDEQ and the FTN intensive surveys are compiled in Appendix C.

The two conditions that usually characterize critical periods for DO are high temperatures and low flows. High temperatures decrease DO saturation values and increase rates for oxygen demanding processes (BOD decay, nitrification, and sediment oxygen demand (SOD)). In most systems, low flows cause reaeration rates to be lower. The purpose of selecting a critical period for calibration is so that the model will be calibrated as accurately as possible for making projection simulations for critical conditions.

The model was calibrated to the FTN intensive survey. This period represented the most critical period for DO. The calibration target (i.e., the concentration to which the model was calibrated) for all parameters except DO, was set equal to the concentrations measured during the survey. Organic nitrogen was estimated as TKN minus the ammonia nitrogen value.

The calibration target for DO at each measurement site was set to the estimated daily minimum DO + 1 mg/L, which is consistent with previous Louisiana DO TMDLs. At Station 272, the daily minimum DO for the sampling day was taken directly from continuous monitoring data. For other sites with only instantaneous DO measurements, daily minimum DO values were estimated using the assumption that, for any given time of day, the ratio of instantaneous DO to the minimum DO that day was the same between the continuous monitoring site (Station 272) and other measurement sites. Each instantaneous DO measurement was divided by the ratio of instantaneous DO to daily minimum DO at Station 272 for the time of day when the instantaneous DO was measured. These calculations are shown in Appendix E.

4.3 Temperature Correction of Kinetics (Data Type 4)

The temperature correction factors used in the model were consistent with the Louisiana Technical Procedures Manual (the “LTP”; Aquillard and Duerr 2006). These correction factors were:

1. Correction for BOD decay: 1.047 (value in LTP is same as model default).
2. Correction for SOD: 1.065 (value in LTP is same as model default).
3. Correction for ammonia N decay: 1.070 (specified in Data Group 4).
4. Correction for organic N decay: 1.020 (not specified in LTP; model default used).
5. Correction for reaeration: Automatically calculated by the model.

4.4 Hydraulics (Data Type 9)

The hydraulics were specified in the input for the LA-QUAL model using the power functions (width = $a * Q^b + c$ and depth = $d * Q^e + f$). The typical width and depth of the reaches of the Flat River model were based on cross-section and flow data collected by FTN during its intensive survey (Table 4.1). A Relationship was developed between flow and depth (shown in Appendix F). This relationship was used to estimate depths for reaches where cross-sections were not measured during the FTN intensive survey, as well as a depth for Reach 1 under low flow conditions (the FTN intensive survey cross section at Station 363 was measured during high flow conditions). Widths for these reaches were measured from digital orthagonal quarter quads (Appendix F).

Table 4.1. Flat River width and depth measurements from FTN intensive survey.

Survey Section	Width (ft)	Mean Depth (ft)	Flow (cfs)
363	43	1.805814	41.89286*
390	30	1.476667	
390	35	2.91	110.088*
389	23	1.069565	
272	37.5	1.324	7.436
100406-A	39.4	0.556091	

* These flows include releases from Black Bayou Reservoir.

4.5 Initial Conditions (Data Type 11)

Because temperature is not being simulated in the model, the temperature for the reach was specified in the initial conditions for LA-QUAL. The input data for initial temperature and DO concentrations are shown in Appendix J.

For constituents not being simulated, the initial concentrations were set to zero. Otherwise the model would have assumed a fixed concentration of those constituents and the model would have included effects of the unmodeled constituents on the modeled constituents.

4.6 Water Quality Kinetics (Data Types 12 and 13)

Kinetic rates used in LA-QUAL include reaeration rates, CBOD decay rates, nitrification rate, and mineralization rates (organic nitrogen decay). The values used in the model input are shown in Appendix J.

For reaeration, the Louisiana Equation (option 15) was specified in the model because it was developed specifically for streams in Louisiana and it has been used successfully in the past for other TMDLs in Louisiana.

The rates for CBOD decay were set to the value of the laboratory decay rate from the FTN intensive survey Station 363. The nitrification rate for Reaches 1-3 and 6-7 was based on analyzing NBOD decay rates measured by LDEQ for agricultural subsegments in the Ouachita and Calcasieu River Basins. The measured NBOD rates were averaged and this computation is shown in Appendix G. For Reaches 4 and 5 (mostly urban land use) the nitrification rate was set to the median of all of the NBOD decay rates measured by LDEQ in the Ouachita and Calcasieu River Basins.

The mineralization rates (organic nitrogen decay) in the model were set to 0.02/day for all reaches. This value was similar to the values shown in Table 5.3 of the "Rates, Constants, and Kinetics" publication (US EPA 1985) for dissolved organic nitrogen being transformed to ammonia nitrogen. The literature values for mineralization rates are shown in Appendix G.

4.7 Nonpoint Source Loads (Data Type 19)

The NPS loads that are specified in the model can be most easily understood as resuspended load from the bottom sediments and are modeled as SOD, benthic ammonia source rates, CBOD loads, and organic nitrogen loads. The SOD (specified in data type 12), the benthic ammonia source rates (specified in data type 13), and the mass loads of organic nitrogen and CBODu (specified in data type 19) were all treated as calibration parameters; their values were adjusted until the model output was similar to the calibration target values. The values used as model input are shown in Appendix J.

Typically, these four calibration parameters were adjusted in a specific order based on the interactions between state variables in the model. First, the organic nitrogen loads were adjusted until the predicted organic nitrogen concentrations were similar to the observed concentrations. Organic nitrogen was calibrated first because none of the other state variables will affect the organic nitrogen concentrations. Next, the benthic ammonia source rates were adjusted until the predicted ammonia nitrogen concentrations were similar to the observed concentrations. Then the CBODu loads were adjusted until the predicted CBODu concentrations were similar to the observed concentrations. Finally, the SOD rates were adjusted until the predicted DO concentrations were similar to the observed concentrations. The SOD rate was not adjusted below 0.5 $g/m^2/day$. The DO was calibrated last because all of the other state variables affect DO.

4.8 Headwater, Tributary, and Point Source Flow (Data Types 16 and 24)

Headwater inflow for Flat River was set to 0.047 cms based on flow measured at Station 272 during the FTN intensive survey (Appendix H). Flow measured during the FTN intensive survey at the upstream-most Station (363) included releases from Black Bayou Reservoir. Local observers indicated that releases from Black Bayou Reservoir rarely occurred. Therefore, the measured flow at Station 363 was deemed not representative of the low flow, critical conditions that we desired to model.

The tributary inflow for Red Chute Bayou was set to 0.208 cms based on flows reported for September 1 at USGS Gage 07349860 (Red Chute Bayou near Sligo, Louisiana)(Appendix H). Point source flows for River Ridge and Palmetto Park were set to the average monthly flow reported on the dischargers' September 2005 DMRs. No DMRs could be located in EDMS for Elm Grove Jr. High School, so the flow for this point source was set to 0.001 cms (25,000 gpd) based on the general permit.

4.9 Headwater, Tributary, and Point Source Water Quality (Data Types 16, 17, 24, and 25)

Concentrations of DO, CBODu, organic nitrogen, and ammonia nitrogen were specified in the model for the headwater, tributary, and point sources. DO concentration for the Flat River headwater was set to the estimated minimum daily DO + 1 (see Section 4.2). The remaining water quality for the Flat River headwater was set to the concentrations measured at Station 363. The DO concentration for the Red Chute Bayou tributary was set to the value measured at Station 100406-A. The remaining water quality parameters for the Red Chute Bayou tributary were assumed equal to the Flat River headwater, since both streams originate in upper Bossier Parish. Water quality for point sources was set based on the dischargers' permits and DMRs, and the LTP guidance Version 10 (Aguillard and Duerr 2006). The DO concentrations for the River Ridge and Palmetto Park point sources were set to 5 mg/L based on the fact that, according to the LTP, the BOD_5 permit limits for these facilities indicates the use of advanced treatment. The DO concentration for Elm Gove Jr. High School was set to 2 mg/L based on the fact that, according to the LTP, the BOD_5 permit limit for this facility indicates use of secondary level treatment (Aguillard and Duerr 2006). CBODu concentrations for River Ridge and Palmetto Park point sources were set to 2.3 times the monthly average BOD_5 permit limits for the facilities. The CBODu concentration for the Elm Ridge Jr. High point source was set to 2.3 times the general permit BOD_5 limit. Organic nitrogen and ammonia concentrations for the point sources were set based on LTP guidance using their BOD_5 permit limits and information about the facilities.

4.10 Model Results for Calibration

Plots of predicted and observed water quality for the calibration are presented in Appendix I and a printout of the LA-QUAL output file is included as Appendix J. The calibration was considered to be acceptable based on the amount of data that were available.

5.0 WATER QUALITY MODEL PROJECTION

US EPA's regulations at 40 CFR 130.7 require the determination of TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. Therefore, the calibrated model was used to project water quality for critical conditions. The identification of critical conditions and the model input data used for critical conditions are discussed below.

5.1 Identification of Critical Conditions

Section 303(d) of the Federal Clean Water Act and US EPA's regulations at 40 CFR 130.7 both require the consideration of seasonal variation of conditions affecting the constituent of concern and the inclusion of a MOS in the development of a TMDL. For the TMDLs in this report, analyses of LDEQ long-term ambient data were used to determine critical seasonal conditions. A combination of implicit and explicit MOS was used in developing the projection model.

Critical conditions for DO have been determined for Louisiana waterbodies in previous TMDL studies. The analyses concluded that the critical conditions for stream DO concentrations occur during periods with negligible nonpoint runoff, low stream flow, and high stream temperature.

When the rainfall runoff (and nonpoint loading) and stream flow are high, turbulence is higher due to the higher flow and the stream temperature is lowered by the cooler precipitation and runoff. In addition, runoff coefficients are higher in cooler weather due to reduced evaporation and evapotranspiration, so that the high flow periods of the year tend to be the cooler periods. DO saturation values are; of course, much higher when water temperatures are cooler, but BOD decay rates are much lower. For these reasons, periods of high loading are periods of higher reaeration and DO but not necessarily periods of high BOD decay.

LDEQ interprets this phenomenon in its TMDL modeling by assuming that the annual nonpoint loading, rather than loading for any particular day, is responsible for the accumulated benthic blanket of the stream, which is, in turn, expressed as SOD and/or resuspended BOD in the model. This accumulated loading has its greatest impact on the stream during periods of higher temperature and lower flow.

According to the LTP (Aguillard and Duerr 2006) critical summer and winter conditions in DO TMDL projection modeling are simulated by using the annual 7Q10 flow or 0.1 cfs, whichever is higher, for all headwaters, and 90th percentile temperature for the season. Model loading is from perennial tributaries, point sources, SOD, and resuspension of sediments.

In reality, the highest temperatures occur in July and August and the lowest stream flows occur in October through November. The combination of these conditions plus the impact of other conservative assumptions regarding rates and loadings yields an implicit MOS that is not quantified. Over and above this implicit MOS, explicit MOS of 10% for NPS, and 20% for point sources were incorporated into the TMDLs in this report to account for model uncertainty.

5.2 Temperature Inputs

The LTP (Aguillard and Duerr 2006) specified that the critical temperature should be determined by calculating the 90th percentile seasonal temperature for the waterbody being modeled. LDEQ Station 272 on Flat River had long term temperature records. The temperatures for the projection models were set to the 90th percentile summer or winter temperatures determined for Station 272 (29.3°C summer, 20.8°C winter). These values were specified in Data Type 11 in the models and for all inflows (Appendices N and O). The values used to calculate the 90th percentile temperatures are shown in Appendix K.

5.3 Headwater and Tributary Inputs

The inputs for the headwaters and tributaries for the projection simulations were based on guidance in the LTP (Aguillard and Duerr 2006). As specified in the LTP, the DO concentration for the headwater inflow was set to 90% saturation at the critical temperature (Section 5.2). The DO concentration for the tributary was set to it’s DO water quality criteria, 3 mg/L summer and 5 mg/L winter. Headwater concentrations for other parameters were set to calibration values. Headwater flow was set to either the 7Q10 flow or 0.1 cfs, whichever was greater.

Summer and winter 7Q10 flows were estimated for the headwater and tributary. A basin 7Q10 flow per square mile was used to estimate the 7Q10 tributary inflow. The basin 7Q10 flow per square mile was estimated as the reported average annual and December through February 7Q10 flows for the USGS gage at Red Chute Bayou near Sligo, Louisiana (07349860) (USGS 2003), divided by the gage drainage area (Appendix L). The basin 7Q10 flow per square mile for summer was 0.003 cfs/sq mi and for winter was 0-045 cfs/sq mi. The summer and winter 7Q10 flows for the headwater were estimated from the Red Chute Bayou seasonal 7Q10s using a ratio of Flat River to Red Chute Bayou flows developed from historical flow data (Appendix L). The estimated headwater 7Q10 flows used in the projection models were 0.12 cfs for summer and 1.22 cfs for winter.

It was assumed that the headwater and tributary water quality would improve with reductions of NPS in the watershed. For the projection simulations, the headwater and tributary concentrations of CBODu, organic nitrogen, and ammonia nitrogen were reduced from the calibration simulation by the same percentages as the reduction of nonpoint source loads (see Section 5.5 for reductions applied to nonpoint source loads). The values used as model inputs for headwater and tributary concentrations are shown in Appendices N and O.

5.4 Point Source Inputs

In the projection models, the point source flows were set to 1.25 times either the facility design flow (Palmetto Park) or the general permit maximum flows (River Ridge and Elm Grove Jr. High). CBODu concentrations for the point sources were set to 2.3 times the facility BOD_5 permit limits. All other water quality concentrations for the point sources were set to the values used in the calibration model.

5.5 Nonpoint Source Loads

Because the initial projection simulations showed low DO values, the NPS loadings were reduced until all of the predicted DO values were equal to or greater than the water quality criterion of 5.0 mg/L. The same percent reduction was applied to the SOD and NPS mass loads of CBODu and organic nitrogen. SOD was not reduced below 0.5 g/m^2/day. The values used as model input in the projection simulations are shown in Appendices N and O.

5.6 Other Inputs

The only model inputs that were changed from the calibration to the projection simulation were the inputs discussed above in Sections 4.2 through 4.5. Other model inputs (e.g., hydraulic coefficients, decay rates, reaeration equations, etc.) were unchanged from the calibration simulation.

5.7 Model Results for Projection

Plots of predicted water quality for the projection are presented in Appendix M and printouts of the LA-QUAL output files are included as Appendix N (summer projection) and Appendix O (winter projection).

Oxygen demanding load reductions were required to meet the DO criterion. NPS load reductions of 75% to 92.5% were required to bring the predicted summer DO values to at least 5.0 mg/L. Reductions of 3% and 49% were required to bring the predicted winter DO values to at lest 5.0 mg/L. These percent reductions for NPS loads represent percentages of the entire NPS loading, not percentages of the manmade NPS loading. The NPS loads in this report were not divided between natural and manmade because it would be difficult to estimate natural NPS loads for the study area.

6.0 DO TMDL CALCULATIONS

6.1 DO TMDL

A TMDL for DO has been calculated for the Flat River subsegment based on the results of the projection simulations. The DO TMDL is presented as oxygen demand from CBODu, organic nitrogen, ammonia nitrogen, and SOD. Summaries of the summer and winter loads for Flat River are presented in Tables 6.1 and 6.2 (located at the end of this section). The TMDL calculations were performed using a program developed by FTN (Appendices P through R).

LDEQ's position, as supported by the declaratory ruling issued by Secretary Givens in response to the lawsuit regarding water quality criteria for nutrients (Sierra Club v. Givens, 710 So.2d 249 (La. App. 1st Cir. 1997), writ denied, 705 So.2d 1106 (La. 1998), is that when oxygen demanding substances are controlled and limited in order to ensure that the DO criterion is supported, nutrients are also controlled and limited. The implementation of this TMDL through future wastewater discharge permits (if required) and implementation of BMPs to control and reduce runoff of soil and oxygen demanding pollutants from NPS in the watershed will also control and reduce the nutrient loading from those sources.

6.2 Ammonia Toxicity Calculations

Although Subsegment 100406 is not on a 303(d) List for ammonia, the ammonia concentrations predicted by the projection model were checked to make sure that they did not exceed US EPA criteria for ammonia toxicity (US EPA 1999). The US EPA criteria are dependent on temperature and pH. The water temperatures used to calculate the ammonia toxicity criteria for Flat River were the same as the critical temperatures used in the projection simulations. For pH, seasonal averages of the values measured at the Flat River Station 272 were used. The resulting criteria were 1.71 mg/L of ammonia nitrogen for summer and 3.48 mg/L of ammonia nitrogen for winter. None of the instream ammonia nitrogen concentrations predicted by the LA-QUAL model for Flat River were above the criterion. A number of the summer ammonia nitrogen concentrations predicted by the LA-QUAL model for the first reach were above the summer criterion. This indicates that the ammonia nitrogen loadings that will maintain the DO standard may not be low enough that the US EPA ammonia toxicity criteria will not be exceeded under critical conditions. The ammonia toxicity calculations are shown in Appendix S.

6.3 Summary of NPS Reductions

In summary, the projection modeling used to develop the TMDLs above showed that NPS loads needed to be reduced by 75% to 92.5% to maintain the DO criterion in Flat River during summer, and by 3% and 49% to maintain the DO criterion during winter. Reductions of point source discharges are not required as a result of this TMDL.

6.4 Seasonal Variation

As discussed in Section 5.1, critical conditions for DO in Louisiana waterbodies have been determined to be when there is negligible nonpoint runoff and low stream flow combined with high water temperatures. In addition, the model accounts for loadings that occur at higher flows by modeling sediment oxygen demand. Oxygen demanding pollutants that enter the waterbodies during higher flows settle to the bottom and then exert the greatest oxygen demand during the high temperature seasons.

6.5 Margin of Safety

The MOS accounts for any lack of knowledge or uncertainty concerning the relationship between load allocations and water quality. As discussed in Section 5.1, the highest temperatures occur in July through August, the lowest stream flows occur in October through November. The combination of these conditions, in addition to other conservative assumptions regarding rates and loadings, yields an implicit MOS, which is not quantified. In addition to the implicit MOS, the TMDL in this report includes an explicit MOS of 10% for NPS loads.

Table 6.1. Summer DO TMDL for Subsegment 100406.

	Oxygen Demand(kg/day) from:					Oxygen Demand (lbs/day) from:					Percent Reduction Needed
	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	
Point Sources											
WLA	NA	117.41	50.4	29.42	197	NA	258.30	110.88	64.72	433.91	**0%**
MOS	NA	14.68	6.30	3.69	24	NA	32.30	13.86	8.12	54.25	NA
FG	NA	14.68	6.30	3.69	24	NA	32.30	13.86	8.12	54.25	NA
Nonpoint Sources											
LA	1732.76	186.46	57.54	1.22	1977	3812.07	410.21	126.59	2.68	4351.53	**75%, 92.5%**
MOS	216.59	23.31	7.19	0.15	247	476.50	51.28	15.82	0.33	543.95	NA
FG	216.59	23.31	7.19	0.15	247	476.50	51.28	15.82	0.33	543.95	NA
TMDL	2165.94	379.85	134.92	72.65	2719	4765.07	835.67	296.82	159.83	5981.84	NA

Table 6.2. Winter DO TMDL for Subsegment 100406.

	Oxygen Demand (kg/day) from:					Oxygen Demand (lbs/day) from:					Percent Reduction Needed
	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	
Point Sources											
WLA	NA	107.39	40.29	23.61	171.29	NA	236.26	88.64	51.94	376.84	0%
MOS	NA	13.42	5.04	2.95	21.41	NA	29.52	11.09	6.49	47.10	NA
FG	NA	13.42	5.04	2.95	21.41	NA	29.52	11.09	6.49	47.10	NA
Nonpoint Sources											
LA	3335.25	593.44	185.73	2.76	4117.19	7337.55	1186.77	408.61	6.07	9087.82	3%, 49%
MOS	416.90	74.18	23.22	0.35	514.65	917.18	163.20	51.08	0.77	1132.23	NA
FG	416.90	74.18	23.22	0.35	514.65	917.18	163.20	51.08	0.77	1132.23	NA
TMDL	41690.5	876.03	282.54	32.97	5360.6	9171.91	1927.27	621.59	72.53	11793.32	NA

Table 6.3. Flows, concentrations, and loads for point sources included in DO TMDL.

NPDES Number	Name of discharger	Flow rate (gallons per day)	Concentrations			Loads*		
			BOD_5 or COD (mg/L)	Ammonia nitrogen (mg/L)	Organic nitrogen (mg/L)	BOD_5 or COD (lbs/day)	Ammonia nitrogen (lbs/day)	Organic nitrogen (lbs/day)
LAG560083	River Ridge Subdivision	50000	20	7	3	8.23	2.89	1.23
LA0102890	Palmetto Park	400000	10	3	7	33.37	10.02	23.37
LAG540188	Elm Grove Jr. High	25000	30	10	5	6.40	2.13	1.06
LAG480035	La Military Dept	46000	200	0	0	33.09	0	0
LAG480223	La Machinery Co. Inc.	1000	200	0	0	0.58	0	0
LAG540038	Jeff Hall Ministries	10000	30	0	0	2.43	0	0
LAG540494	Maplewood Park	25000	30	0	0	6.26	0	0
LAG541141	Magnolia Chase Subdivision	21000	30	0	0	5.21	0	0
LAG541272	Haymeadow Subdivision	9000	30	0	0	2.20	0	0
LAG541293	St Charles Court	23000	30	0	0	5.80	0	0
LAG560063	Oak Creek Devel	50000	20	0	0	8.34	0	0
LAG470050	Red River Motor Co	2000	45	0	0	0.63	0	0
Total Loads:						112.54	15.02	25.66

*Loads of organic nitrogen and ammonia nitrogen in this table represent loads of nitrogen, not oxygen demand.

7.0 NUTRIENT TMDL DEVELOPMENT

7.1 Seasonality and Critical Conditions

EPA's regulations at 40 CFR 130.7 require the determination of TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. Also, both Section 303(d) of the Clean Water Act and regulations at 40 CFR 130.7 require TMDLs to consider seasonal variations for meeting water quality standards. Aquatic life impairments typically occur as a result of long term exposure to elevated nutrient concentrations rather than short term fluctuations in nutrient concentrations. These nutrient TMDLs were developed for average annual conditions. The most obvious result of nutrients is algal blooms. When the algae die, the resultant BOD consumes oxygen, which adversely affects aquatic life. The effect occurs in a short time but the build-up of nutrients and the conditions to start the algal bloom may occur over an extended time.

7.2 Water Quality Targets

Since there are no numeric nutrient criteria for Subsegment 100406 (Flat River), the listing for nutrients was addressed by comparing total nitrogen ($TKN+NO_2+NO_3$) and total phosphorus concentrations in Flat River with values from LDEQ references streams in the South Central Plain Ecoregion (the ecoregion in which Flat River is located). The reference stream data consisted of samples collected from eight streams during low flow conditions in the mid 1990s (Smythe 1999). These data are shown in Table 7.1. The data for Flat River consisted of summer (May through September) LDEQ ambient monitoring data for Station 272 (Flat River east of Taylortown, Louisiana). These data are shown in Table 7.2.

Table 7.1. Data from LDEQ reference streams in the South Central Plains Ecoregion.

Waterbody	NO_2+NO_3 (mg/L)	TKN (mg/L)	Total N (mg/L)	Total P (mg/L)
Meridian Creek near Conway in Union Parish [A]	0.24	0.91	1.15	0.21
Saline Bayou near Saline in Beinville Parish	0.08	0.53	0.61	0.04
Middle Fork Bayou D'Arbonne near Bernice in Claiborne Parish	< 0.01	0.94	0.95	< 0.02
Beaucoup Creek near Chester in Winn Parish	0.02	0.76	0.78	0.08
Kisatchie Bayou in Natchitoches Parish [B]	0.23	0.60	0.83	0.06
Six Mile Creek near Grant in Allen Parish	0.10	0.19	0.29	0.09
Pearl Creek near Burr Ferry in Vernon Parish	0.08	0.46	0.54	0.05
Calcasieu River near Oberlin in Allen Parish	0.08	0.48	0.56	0.11
		Minimum	0.29	< 0.02
		Median	0.70	0.07
		Mean	0.71	0.08
		Maximum	1.15	0.21

Note: A = averages of two samples, B = averages of three samples.

7.3 Nutrient Analysis

The data for Flat River that was used in the comparison to the reference streams consisted of summer (May through September) LDEQ ambient monitoring data for Station 272 (Flat River east of Taylortown, Louisiana). These data are shown in Table 7.2.

Concentrations of total nitrogen and total phosphorus in the reference streams and Flat River were compared by calculating selected statistics (minimum, mean, and maximum) for each data set. These statistics are shown in Tables 7.1 and 7.2. Comparison of the statistics for these data sets show that the summer concentrations of both total phosphorus and total nitrogen in Flat River are greater than the reference stream concentrations. As a result, reduction of the Flat River total phosphorus and total nitrogen loads is recommended.

Table 7.2. Flat River summer data.

Date	Total P (mg/L)	NO2+NO3 (mg/L)	TKN (mg/L)	Total N (mg/L)
11-Jun-90	0.32	< 0.02	0.93	0.95
14-Aug-90	0.23	0.03	1.05	1.08
11-Jun-91	0.15	0.06	0.65	0.71
13-Aug-91	0.20	< 0.02	0.61	0.63
15-Jun-92	0.21	0.23	0.95	1.18
11-Aug-92	0.16	0.03	0.67	0.70
14-Jun-93	0.24	0.08	1.06	1.14
9-Aug-93	0.32	0.28	0.84	1.12
13-Jun-94	0.22	0.26	0.79	1.05
8-Aug-94	0.43	0.36	1.06	1.42
12-Jun-95	0.21	0.46	0.94	1.40
15-Aug-95	0.18	0.08	0.91	0.99
10-Jun-96	0.17	0.30	1.21	1.51
13-Aug-96	0.14	0.09	0.36	0.45
9-Jun-97	0.19	1.09	1.02	2.11
12-Aug-97	0.25	0.39	0.85	1.24
14-May-02	0.12	0.16	0.73	0.89
11-Jun-02	0.20	0.12	0.64	0.76
9-Jul-02	0.17	0.10	0.95	1.05
5-Aug-02	0.14	< 0.02	0.41	0.43
17-Sep-02	0.18	0.09	0.53	0.62
Min	**0.12**			**0.43**
Mean	**0.21**			**1.02**
Max	**0.43**			**2.11**

7.4 Nutrient TMDLs

The TMDL for total phosphorus and total nitrogen for Subsegment 100406 was calculated based on allowable loads of nitrogen from the DO modeling and a naturally occurring ratio of total nitrogen to total phosphorus. The naturally occurring ratio of total nitrogen to total phosphorus was used because the Louisiana Water Quality Standards require that ratio to be maintained in streams and lakes (see Section 2.3). The naturally occurring ratio of total nitrogen to total phosphorus was calculated to be 10 using the median values of total nitrogen and total phosphorus from the reference streams in Table 7.1 (0.70 mg/L and 0.07 mg/L). The allowable loads of total nitrogen were calculated as the simulated loads of organic nitrogen and ammonia nitrogen in the projection simulations plus assumed values of nitrate+nitrite nitrogen. The allowable loads of total phosphorus were then calculated as simply the allowable loads of total nitrogen divided by 10 (the naturally occurring ratio of total nitrogen to total phosphorus). The MOS and FG components for this nutrient TMDL were calculated as 10% each (or 20% combined) of the total loading after including the MOS and FG. The details of these calculations are shown in Appendix T and the results are summarized in Table 7.3.

Table 7.3. Nutrient TMDL for Subsegment 100406.

Season	Component	Loads in kg/day		Loads in lbs/day	
		Total Nitrogen	Total Phosphorus	Total Nitrogen	Total Phosphorus
Summer	LA	19.21	1.921	42.35	4.235
	WLA	48.64	4.864	107.22	10.722
	MOS	8.48	0.848	18.7	1.870
	FG	8.48	0.848	18.7	1.870
	TMDL	84.81	8.481	186.97	18.697
Winter	LA	196.56	19.656	433.34	43.334
	WLA	48.64	4.864	107.22	10.722
	MOS	30.65	3.065	67.57	6.757
	FG	30.65	3.065	67.57	6.757
	TMDL	306.50	30.650	675.70	67.570

None of the point source discharges in Subsegment 100406 had permit limits for phosphorus or nitrogen. However, 10 of the 12 point sources in the subsegment included in the DO TMDL were permitted to discharge sanitary wastewater and would be expected to contribute nitrogen and phosphorus loads to the subsegment. Those 10 permits were included in the nutrient TMDL. The nutrient loads for those point sources included in the DO model were taken from the projection models. The nutrient loads for the minor point sources not included in the DO model were estimated using nitrogen concentrations from the LTP associated with the facility BOD5 permit limits. The allowable loads and concentrations for those permits are shown in Table 7.4.

Table 7.4. Point source concentrations and loads for nutrient TMDL.

			Concentrations		Loads	
NPDES Number	**Name of Discharger**	**Flow Rate (gpd)**	**Total Nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**Total Nitrogen (lbs/day)**	**Total Phosphorus (lbs/day)**
LA0102980	River Ridge Subdivision	50000	20.00	2.00	83.44	8.344
LAG560083	Palmetto Park	400000	19.98	2.00	10.27	1.027
LAG540188	Elm Grove Jr. High	25000	24.97	2.50	6.66	0.666
LAG540038	Jeff Hall Ministries	10000	25.10	2.51	2.51	0.251
LAG540494	Maplewood Park	25000	24.98	2.50	6.46	0.646
LAG541141	Magnolia Chase Subdivision	21000	25.00	2.50	5.42	0.542
LAG541272	Haymeadow Subdivision	9000	24.98	2.50	2.29	0.229
LAG541293	St Charles Court	23000	24.97	2.50	6.04	0.604
LAG560063	Oak Creek Devel	50000	20.01	2.00	10.52	1.052
LAG470050	Red River Motor Co	2000	25.10	2.51	0.42	0.042
Subsegment 100406 TOTAL LOADS:					107.22	10.722

Although this TMDL specifies a WLA for nutrients, it is recommended that as a first step to implement this TMDL, the point sources should be given nutrient monitoring requirements in their permits to determine if the point sources are causing or contributing nutrients. However, final decisions for point source nutrient limitations will be made by LDEQ on a case-by-case basis during the re-issuance of each permit.

7.5 Summary of NPS Reductions

The LAs reported in Table 7.3 were calculated as the TMDL-FG-WLA. The analysis outlined in Section 7.3 above indicated that both total phosphorus and total nitrogen loads need to be reduced. Up to a 62% reduction in total phosphorus loads would be needed for Flat River average total phosphorus concentration (Table 7.2) to be similar to the reference stream average concentration (Table 7.1), and up to a 30% reduction in total nitrogen loads would be needed for Flat River average total nitrogen concentration to be similar to the reference stream average concentration.

The DO TMDL establishes load limitations for oxygen-demanding substances and goals for reduction of those pollutants. When oxygen-demanding substances are controlled and limited in order to ensure that the DO criterion is supported, nutrients are also controlled and limited. The implementation of the DO TMDL through future wastewater discharge permits (if required) and implementation of BMPs to control and reduce runoff of soil and oxygen-demanding pollutants from non-point sources in the watershed will also control and reduce the nutrient loading from those sources.

8.0 SENSITIVITY ANALYSES

All modeling studies necessarily involve uncertainty and some degree of approximation. Therefore, of value to consider the sensitivity of the model output to changes in model coefficients, and in the hypothesized relationships among the parameters of the model. The sensitivity analyses were performed by allowing the LA-QUAL model to vary one input parameter at a time while holding all other parameters to their original value. The calibration simulation was used as the baseline for the sensitivity analysis. The percent change of the model's minimum DO projections to each parameter is presented in Table 8.1. Each parameter was varied by ±30%, except for temperature, which were varied ±2ºC.

Values reported in Table 8.1 are sorted by percentage variation of minimum DO from largest percentage variation to smallest. Reaeration, organic nitrogen, velocity, and tributary flows were the parameters to which DO was most sensitive.

Table 8.1. Summary of results of sensitivity analyses.

Parameter	Change in Parameter	Min DO (mg/L)	Change in DO
Baseline	--	1.09	N/A
Waterbody Reaeration	-30	0.88	-19.27%
Benthal Demand	-30	1.3	19.27%
Waterbody Reaeration	30	1.29	18.35%
Benthal Demand	30	0.94	-13.76%
Headwater DO	30	1.19	9.17%
Headwater DO	-30%	1	-8.26%
Initial Temperature	-2 deg C	1.17	7.34%
Waterbody Depth	-30	1.17	7.34%
Initial Temperature	2 deg C	1.02	-6.42%
Waterbody Depth	30	1.05	-3.67%
Headwater Flow	30	1.12	2.75%
Headwater Flow	-30	1.06	-2.75%
CBOD Aerobic Decay Rate	-30	1.1	0.92%
Headwater CBOD	-30	1.1	0.92%
Ammonia Decay Rate	-30	1.09	0.00%
Headwater Ammonia	-30	1.09	0.00%
Headwater Organic Nitrogen	-30	1.09	0.00%
Non-Point Source CBOD	-30	1.09	0.00%
Non-Point Source Organic N	-30	1.09	0.00%
Organic Nitrogen Decay Rate	-30	1.09	0.00%
Waste Load Ammonia	-30	1.09	0.00%
Waste Load CBOD	-30	1.09	0.00%
Waste Load DO	-30	1.09	0.00%
Waste Load Flow	-30	1.09	0.00%
Waste Load Organic Nitrogen	-30	1.09	0.00%
Ammonia Decay Rate	30	1.09	0.00%
CBOD Aerobic Decay Rate	30	1.09	0.00%
Headwater Ammonia	30	1.09	0.00%
Headwater CBOD	30	1.09	0.00%
Headwater Organic Nitrogen	30	1.09	0.00%
Non-Point Source CBOD	30	1.09	0.00%
Non-Point Source Organic N	30	1.09	0.00%
Organic Nitrogen Decay Rate	30	1.09	0.00%
Waste Load Ammonia	30	1.09	0.00%
Waste Load CBOD	30	1.09	0.00%
Waste Load DO	30	1.09	0.00%
Waste Load Flow	30	1.09	0.00%
Waste Load Organic Nitrogen	30	1.09	0.00%

9.0 OTHER RELEVANT INFORMATION

These TMDLs have been developed to be consistent with the State antidegradation policy (LAC 33:IX.1109.A).

This TMDL report does not include an implementation plan. Implementation plans are not required for TMDLs under current federal regulations. Implementation plans can be developed most effectively and efficiently on the state and local level.

LDEQ will work with other agencies such as local Soil Conservation Districts to implement nonpoint source BMPs in the watershed through the 319 programs. LDEQ will also continue to monitor the waters to determine whether standards are being attained.

In accordance with Section 106 of the federal Clean Water Act, and under the authority of the Louisiana Environmental Quality Act, the LDEQ has established a comprehensive program for monitoring the quality of the State's surface waters. The LDEQ Surveillance Section collects surface water samples at various locations, utilizing appropriate sampling methods and procedures for ensuring the quality of the data collected. The objectives of the surface water monitoring program are to determine the quality of the State's surface waters, to develop a long-term data base for water quality trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program is used to develop the State's biennial 305(b) report (Water Quality Inventory) and the 303(d) list of impaired waters. This information is also utilized in establishing priorities for the LDEQ nonpoint source program.

The LDEQ has implemented a watershed approach to surface water quality monitoring. Through this approach, the entire state is sampled over a 4-year cycle. Long-term trend monitoring sites at various locations on the larger rivers and Lake Pontchartrain are sampled throughout the 4-year cycle. Sampling is conducted on a monthly basis to yield approximately 12 samples per site each year the site is monitored. Sampling sites are located where they are considered to be representative of the waterbody. Under the current monitoring schedule, approximately one half of the State's waters are newly assessed for each 305(b) and 303(d) listing biennial cycle, with sampling occurring statewide each year. The 4-year cycle follows an initial 5-year rotation that covered all basins in the state according to the TMDL priorities. This will allow the LDEQ to determine whether there has been any improvement in water quality following implementation of the TMDLs. As the monitoring results are evaluated at the end of each year, waterbodies may be added to or removed from the 303(d) list.

10.0 PUBLIC PARTICIPATION

Federal regulations require USEPA to notify the public and seek comment concerning TMDLs it prepares. The TMDLs in this report were developed under contract to USEPA, and USEPA held a public review period seeking comments, information, and data from the public and any other interested parties. The notice for the public review period was published in the Federal Register on October 25, 2007, and the review period closed on November 26, 2007.

Comments were received from LDEQ. These comments were used to revise this TMDL report. The comments and responses to these TMDLs are included in a separate document that includes comments on similar TMDLs with the same public review period.

USEPA will submit the final version of these TMDLs to LDEQ for implementation and incorporation into LDEQ's current water quality management plan.

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